§ 00 · MEETING DELLA STRUMENTAZIONE ELT A GUIDA ITALIANA (MORFEO E ANDES)

From *Neptunes* to *Earths*

Why ANDES @ ELT will redefine atmospheric characterization, and where the K_p wall waits for us


Francesco Amadori
UNITO · INAF-OATO


Paolo Giacobbe
INAF-OATO


Matteo Brogi
UNITO · INAF-OATO

§ 01 · THE FIELD 01 / 07

Three generations of targets

YESTERDAY
Hot Jupiters
$K_p \geq 150$ km/s · easy HR signal

TODAY
Warm Neptunes
$K_p \approx 100$ km/s · WASP-107b is here

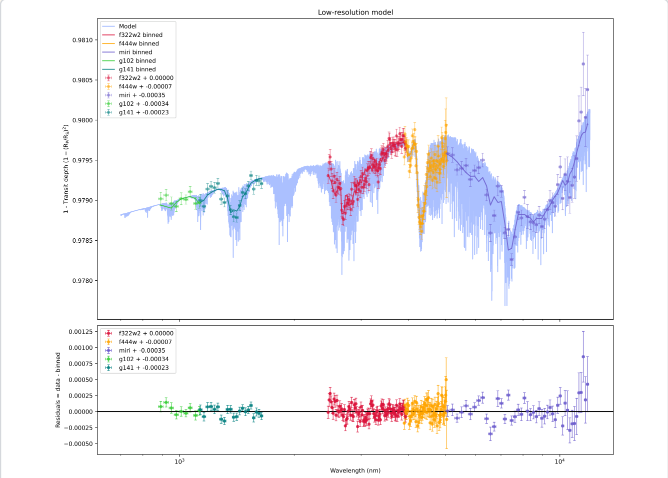
TOMORROW
Sub-Neptunes & rocky
$K_p \leq 60$ km/s · ANDES territory

§ 02 · THE CASE STUDY 02 / 07

WASP-107b, a warm Neptune

MASS	0.096 M_J
RADIUS	0.98 R_J
PERIOD	5.72 d
EQUILIBRIUM T	525 K
DENSITY	0.135 g/cm³

§ 03 · LR RETRIEVAL 03 / 07



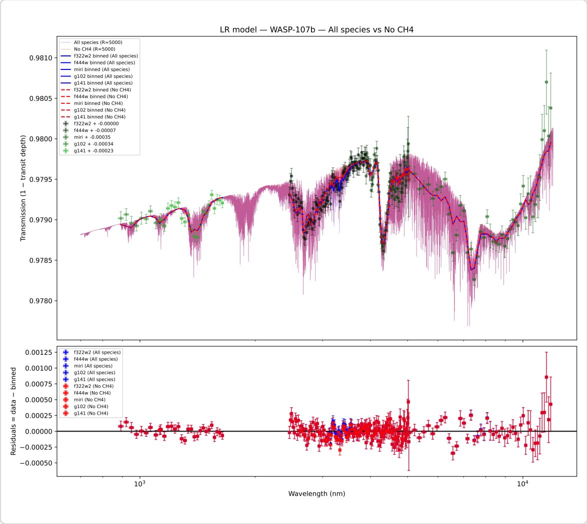
GUIBRUSHR · HST/WFC3 + JWST NIRCam + MIRI

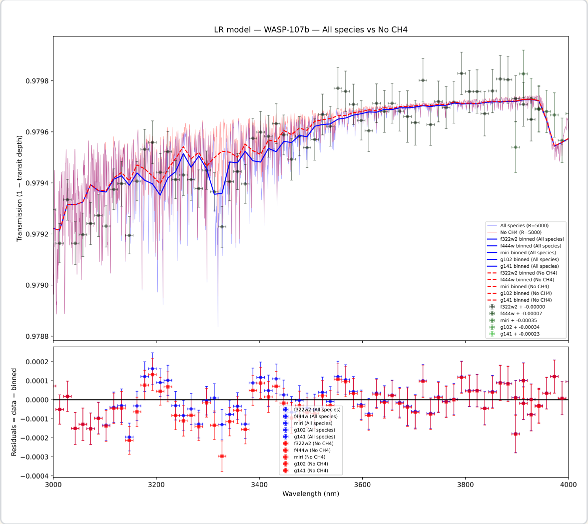
STRONG DETECTION: H_2O, CO, CO_2, SO_2
WEAK DETECTION: CH_4, NH_3
NO DETECTION: H_2S

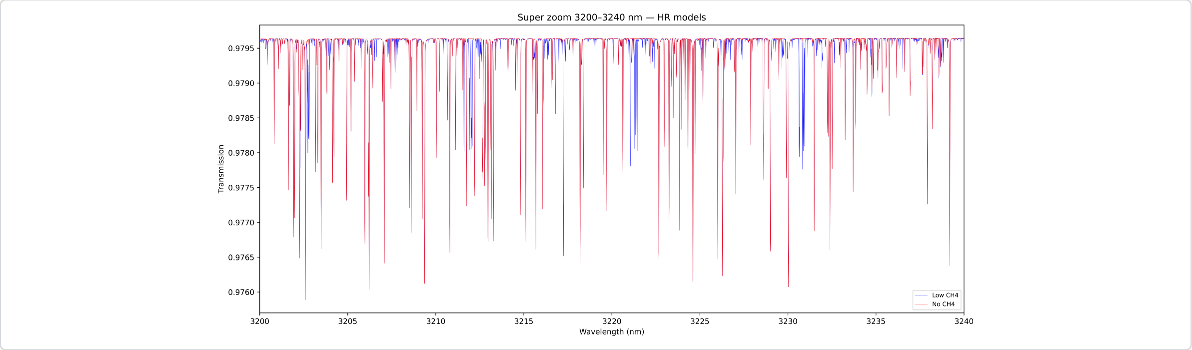
§ 04 · ZOOM IN · FROM LR TO HR 04 / 07

Same molecule, three windows, and resolution decides

— baseline model · — same model, no CH_4







At low resolution the two models (baseline vs. *no* CH_4) are indistinguishable inside the error bars. At **R = 45 000** the line forest separates them line by line, finally seeing the single trees.

§ 07 · TAKE-HOME MESSAGE

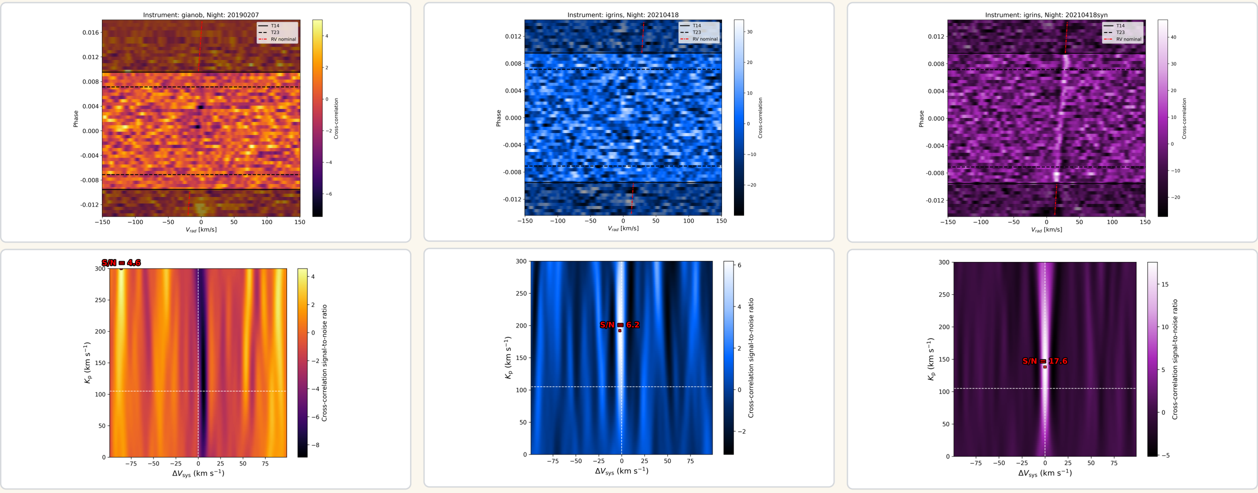
ANDES @ ELT will be a *game-changer* for atmospheric characterization

With **R ≈ 100,000**, **optical-to-NIR coverage** and a **39-m aperture**, *ANDES@ELT* will enable robust characterization of **sub-Neptunes and rocky worlds**. But its flagship targets live in the **low-K_p regime**, where PCA alone is not enough. ***Beating the low-K_p wall now***, with **new techniques, new algorithms and better datasets**, is what will let ANDES deliver on its full promise.

§ 05 · IT IS ALREADY HARD AT K_p = 104 05 / 07

Same pipeline, different instruments, and a synthetic night for reference

GIANO-B — REAL NIGHT · IGRINS — REAL · BEST · IGRINS — SYNTH · LR INJ



S/N ≈ 4.6 — no peak at expected position · S/N ≈ 6.2 — Detection of H_2O · S/N ≈ 17.6 — ≈ 3 × real

GIANO-B nights are unusable: telluric and planetary signals overlap and even 15 PCA components leave significant residuals. One IGRINS night recovers H_2O at an anomalously high K_p (possible dynamical effect). Synthetic data with the LR retrieval model injected recovers H_2O ~3× stronger than real data. Why?

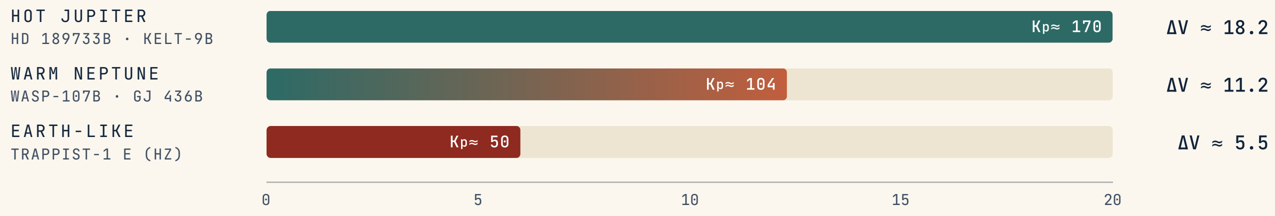
§ 06 · THE K_p WALL 06 / 07

The Doppler shift shrinks faster than the telescope grows

WASP-107 system: $\mathbf{V_{sys}}$ **= 14 km/s**. Barycentric correction applied to all 36 in-transit exposures. The plot below shows the impact of K_p on the ΔV between exposures.

$$V_p(t) = V_{sys} + K_p \cdot \sin(2\pi\, \varphi(t)) - V_{bary}(t)$$

ΔV of the planetary trace across 36 in-transit exposures (km/s)



High K_p: wide ΔV, the trail crosses many pixels and PCA disentangles it from tellurics. **Low K_p:** the trace is nearly stationary, sits in the same eigenvectors as the tellurics, and PCA loses leverage.